Claims

1. A thermal actuator comprising:

a rigid cup having an open top portion, a closed bottom portion, and a centerline passing through the top and bottom portions, wherein

the bottom portion defines a cylindrical cavity having a cavity diameter and filled with thermally responsive wax to an intermediate level within the cup, and

the top portion includes an annular first shoulder extending radially outward to a first shoulder diameter at said intermediate level of the cavity, a first cylindrical wall extending axially at said first shoulder diameter, thereby forming a first notch, an annular second shoulder extending radially outward from the first cylindrical wall to a second shoulder diameter, and a tab wall extending from said second shoulder diameter, thereby forming a second notch;

a plug having

a diaphragm base extending transversely across and sealing the cavity at said intermediate level and

a generally cylindrical stem having a diameter less than the cavity diameter and extending axially beyond the top portion of the cup; and

a guide having

a lower flange portion including a radially outer annular rim bearing against said second shoulder and a radially inner circular ridge bearing against the base of the plug at said cavity diameter, and

a tubular portion surrounding and extending axially beyond the stem;

said tab at the top portion of the cup being crimped radially inwardly over the flange portion of the guide,

whereby the rim of the flange is captured in said second notch and bears against a hard stop defined by the second shoulder of the cup, and the ridge of the flange actuates a first, radially inner seal of the base against the cup first shoulder and extrudes the base into said first notch to from a second, radially outer seal against the first cylindrical wall.

2. The actuator of claim 1, wherein the ridge has a crown that is centered at the cavity diameter.

3. The actuator of claim 2, wherein the crown is substantially flat and transverse to the centerline.

4. The actuator of claim 1, wherein the extruded base fills said first notch and bears against the rim portion of the guide, adjacent the hard stop.

5. The actuator of claim 4, wherein the extruded base that fills said first notch is upturned and is loaded with sealing pressure against said first cylindrical wall and a radially outer portion of said ridge that faces said first cylindrical wall.

6. The actuator of claim 1, wherein the diaphragm base of the plug has a uniform nominal thickness before said tab is crimped, and after the tab is crimped the base extrudes such that an annular portion of the diaphragm base radially outside the ridge is at least twice the thickness of the diaphragm base at said radially inner seal.

7. A pre-assembly thermal actuator comprising:

a rigid cup having an open top portion, a closed bottom portion , and a centerline passing through the top and bottom portions, wherein

the bottom portion defines a cylindrical cavity having a cavity diameter and filled with thermally responsive wax to an intermediate level within the cup, and

the top portion includes an annular first shoulder extending radially outward to a first shoulder diameter at said intermediate level of the cavity, a first cylindrical wall extending axially at said first shoulder diameter, an annular second shoulder extending radially outward from the first cylindrical wall to a second shoulder diameter, and a tab wall extending from said second shoulder diameter;

a plug axially aligned with the cup, said plug having a radially projecting diaphragm base of uniform thickness, and a generally cylindrical stem extending axially from the base;

a guide axially aligned with the cup, said guide having a lower flange portion including a radially outer annular rim and a radially inner circular ridge, and a tubular portion extending axially from the flange.

8. The actuator of claim 7, wherein the ridge has a crown that is centered at the cavity diameter.

9. The actuator of claim 8, wherein the crown is substantially flat and transverse to the centerline.

10. A thermal actuator for generating an actuation force comprising:

a cup defining a cavity;

a thermally responsive wax deposited in said cavity;

a guide fixed to said cup at a periphery thereof and including a tubular portion extending axially above said cup;

a piston disposed for axial reciprocation in said guide; and

a plug arranged between said wax and said piston to transfer force generated by expansion of said wax to said piston,

wherein said thermal actuator has a mass M and said wax expands in response to an increase in temperature ΔT to generate a force F at said piston sufficient to lift a load having a mass at least 2500 times the mass M of said actuator.

11. The thermal actuator of claim 10, wherein M is less than 8 g and F is greater than 130 N.

12. The thermal actuator of claim 10, wherein ΔT is in the range of 10 to 20 degrees F.

13. The thermal actuator of claim 10, wherein said actuator has a length from an exposed actuator end of said piston to a bottom outside surface of said cup and said piston is axially displaced a distance of at least 10% of said length against said load.

14. A thermal actuator comprising:

a cup defining a cavity;

a thermally responsive wax in said cavity;

a guide fixed to said cup at a periphery thereof and including a tubular portion extending axially above said cup;

a piston disposed for axial reciprocation in said guide, said piston having an actuated end directed toward said wax and a protruding end axially extending from said guide; and

a plug arranged between said wax and the actuated end of said piston to transfer force generated by expansion of said wax to said piston,

wherein said wax expands in response to an increase in temperature ΔT to generate a pressure P at said piston actuated end of at least 180 kg/cm^2.

15. The thermal actuator of claim 14, wherein said pressure P is in the range of 180 – 600 kg/cm^2.

16. The thermal actuator of claim 14, wherein said actuator has a length from an exposed actuator end of said piston to a bottom outside surface of said cup and said pressure P produces an axial displacement of said piston of at least 10% of said length against a load having a weight in the range of 30 to 70 lbs (13.6 to 31.82 kg).